AN-2000 LM5060EVAL Evaluation Board

1 Introduction

The LM5060 evaluation board is designed to demonstrate the capabilities of the LM5060 high side protection controller with low quiescent current. It is intended for evaluation of the functions of the LM5060. One high side N-channel power MOSFET is used. The LM5060 evaluation board schematic is shown in Figure 7. The evaluation board is designed to highlight applications with a small solution size. For more information about LM5060 functional and electrical characteristics, see the *LM5060 High-Side Protection Controller With Low Quiescent Current Data Sheet* (SNVS628).

2 Operating Range

- Maximum Input Voltage, OVP: 37 V
- Minimum Input Voltage, UVLO: 9 V
- Output Current Range: 0A to 5.0A
- Ambient Temperature Range 0°C to 50°C
- Board Size 1.35in x 2.25in

To aid in the design and evaluation of high-side protection controller solutions based on the LM5060, the evaluation board can be re-configured for different input voltage ranges by modifying the under-voltage lock-out (UVLO) and the over-voltage protection (OVP) resistive divider (R1, R2, and R3) as well as the protection transient voltage suppressor diode D1.

The load current capability may be increased above 5A of by changing the value of resistor R4. The PCB layout has not been tested for currents above 5A, so this should only be done with some degree of caution.

Typical evaluation board performance and characteristics curves are shown in Figure 1 through Figure 5. The PCB layout is shown in Figure 9 and Figure 10. Test points are provided to enable easy connection and monitoring of critical signals.

3 Evaluation Board Start-Up

Before applying power to the LM5060 evaluation board, all external connections should be verified. The external power supply must be turned off and connected with proper polarity to the INPUT and GND posts. A load resistor should be connected between the OUTPUT and GND posts as desired. A resistive load keeps the current through Q1 during turn-on relatively low. Electronic load equipment tends to be very low impedance during voltage rise so that the transistor Q1 will see very high currents during turn-on when using such loads. Though resistive loads are suggested for use with the LM5060 evaluation board, electronic loads can be used with caution as well. The output voltage can be monitored with a multi-meter or oscilloscope at the OUTPUT post.

Once all connections to the evaluation board have been verified, input power can be applied. A load resistor or electronic load does not require connection during startup. If the EN test point is pulled high (see the threshold voltage in the *Electrical Characteristics* section of the *LM5060 High-Side Protection Controller With Low Quiescent Current Data Sheet* (SNVS628)), the output voltage will ramp up when an input voltage is applied.

For the evaluation board to start up, the EN pin needs to be pulled high. A lab cable is required from the EN pin to the V_{IN} pin or other voltage source higher than 2.0 V.

Make sure that the external power supply (input voltage power source) is capable of providing enough current to the output load so that the output voltage can be obtained.

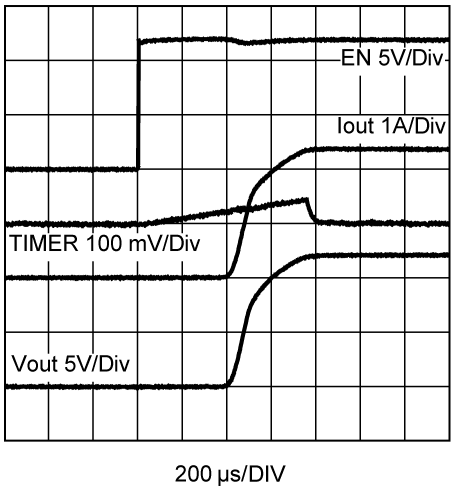

Figure 1. Start-Up Waveforms

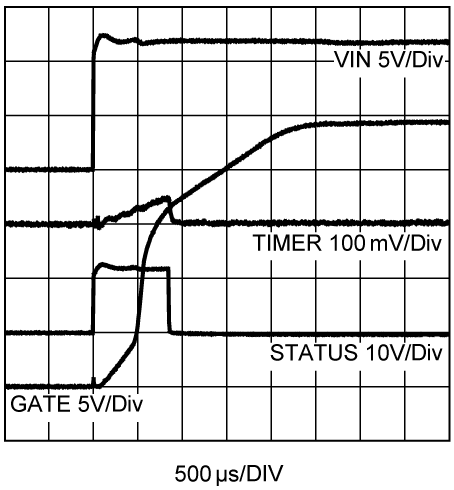

Figure 2. Start-Up Waveforms

4 Inductive Kick-Back Protection

Diode D1 and capacitor C4 serve as inductive kick protection to limit voltage spikes generated when shutting down high currents through Q1 when turning the power MOSFET off. Capacitor C5 is useful for preventing negative voltages on the OUTPUT trace as the MOSFET Q1 is turned off.

5 Enable

The EN test point provided on the LM5060 evaluation board is used to control the LM5060 operation. To shut down the LM5060 evaluation board apply a voltage less than 0.8 V to the EN pin, connect to ground, or open the connection. To start up the LM5060 evaluation board apply a voltage greater than 2.0 V to the EN connection, or connect to V_{IN} directly. If the EN test point is left open, the EN pin internal pull-down will ensure that the LM5060 remains Off. For more details, see the *LM5060 High-Side Protection Controller With Low Quiescent Current Data Sheet* (SNVS628).

6 Under-Voltage Lock-Out (UVLO)

Resistors R1, R2, and R3 set the UVLO from the scaled down value of the input voltage. The LM5060 evaluation board is set to engage UVLO at an input voltage between typically 8.0 V (low threshold) and 8.8 V (high threshold). UVLO is activated when the UVLO pin drops below the high threshold. When UVLO is activated (input voltage is low), the LM5060 turns off MOSFET Q1 but the LM5060 is not latched off. As soon as the UVLO voltage is returned to levels above the high threshold, regular operation will resume.

7 Over-Voltage Protection (OVP)

Resistors R1, R2, and R3 also set the OVP level from the scaled value of the input voltage. The resistors on the LM5060 evaluation board are selected to engage OVP when the input voltage rises above 37.1 V (typical). When OVP is engaged, the LM5060 turns off MOSFET Q1 but the LM5060 is not latched off. As the input voltage reduces below 32.8 V (typical), the MOSFET Q1 will turn back on and the output voltage will go up.

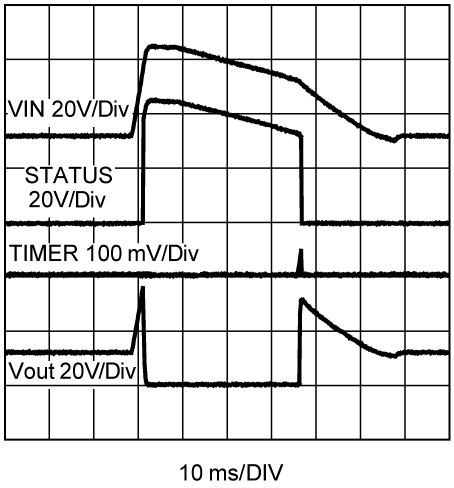

Figure 3. OVP Behavior

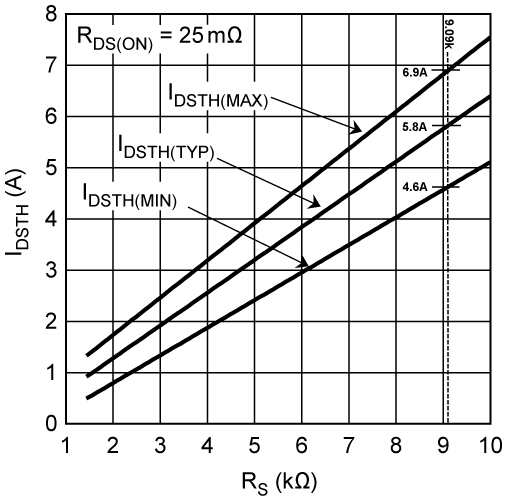

Figure 4. R_S vs I_{DSTH} for $R_{DS(ON)}$ = 25 mΩ

8 Over-Current Protection

The 9.09 kΩ resistor on the SENSE pin (R_S), along with the 0.025Ω of the MOSFET $R_{DS(ON)}$ sets the typical over-current threshold (I_{DSTH}) to approximately 5.8A. This may vary from a low of 4.6A to a high of 6.9A depending on variations in the sense current and the V_{DS} comparator offset voltage. For typical performance for a MOSFET having $R_{DS(ON)}$ of 25 mΩ, see Figure 4.

The 0.10 µF timer capacitor will provide a typical over-current fault detection delay time of 18.2 ms. This may vary from a low of 15.4 ms to a high of 23.5 ms depending on variations in the timer charge current and the timer threshold voltage.

9 Output Status (nPGD)

The output status can be measured at the STATUS connection on the LM5060 evaluation board. The signal will be high when the LM5060 is in a fault condition (SENSE > OUT). STATUS will be low when the LM5060 is activated and not in a fault state (SENSE < OUT). When the LM5060 is shut down by pulling the EN pin low, the nPGD comparator is shut down and the STATUS signal goes high.

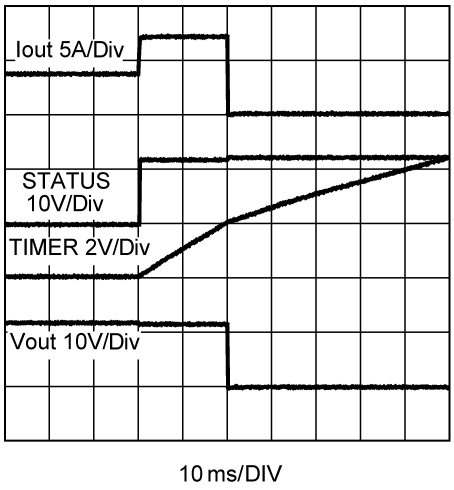

Figure 5. Fault Behavior

10 Gate Circuitry

C3 is optional and can be used to slow down gate transitions for evaluation.

11 Timer Setting

The capacitor C1 sets the start-up time delay, transition time delay, and the Over-Current fault detection delay time. If the voltage on the TIMER cap exceeds the 2.0 V threshold condition, the LM5060 will latch off the MOSFET Q1 and remain off until either the EN, UVLO or V_{IN} (POR) input is switched low and then high.

The 0.10 µF(100 nF) timer capacitor will provide a typical start-up delay time of 33.3 ms, a typical transition delay time of 15.5 ms, and a typical over-current fault detection delay time of 18.2 ms.

12 Component Selection

Before changing the default components and for information regarding component selection, see the *LM5060 High-Side Protection Controller With Low Quiescent Current Data Sheet* (SNVS628).

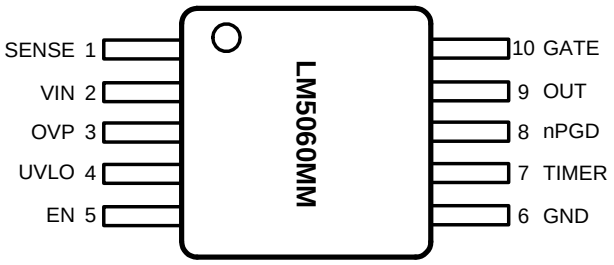

Figure 6. Connection Diagram

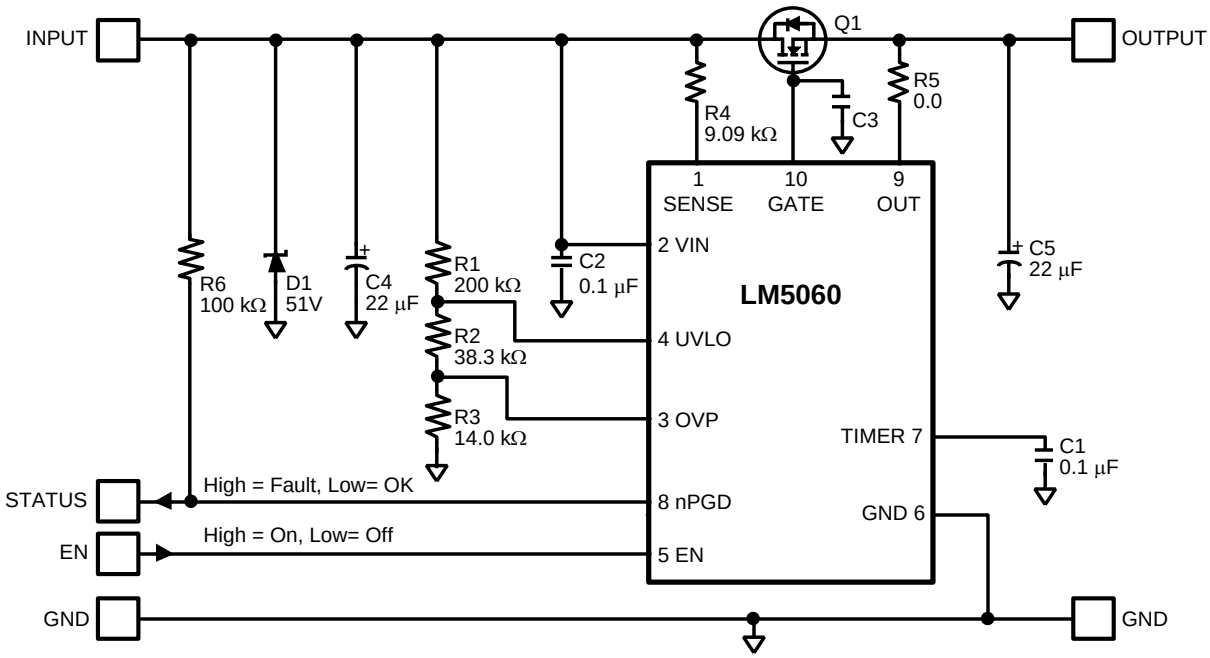

Figure 7. Schematic Diagram

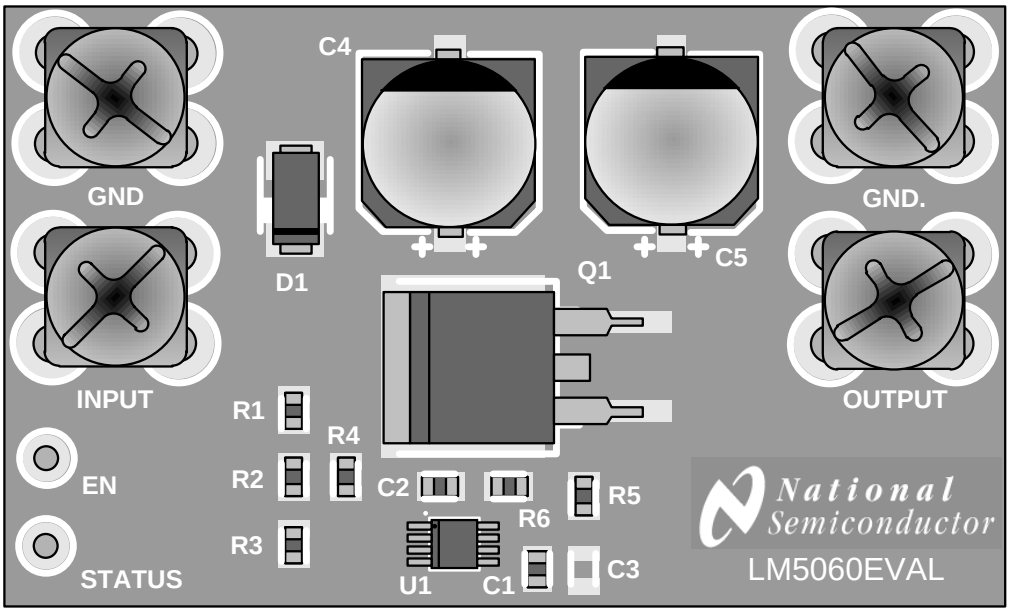

Figure 8. Component Placement

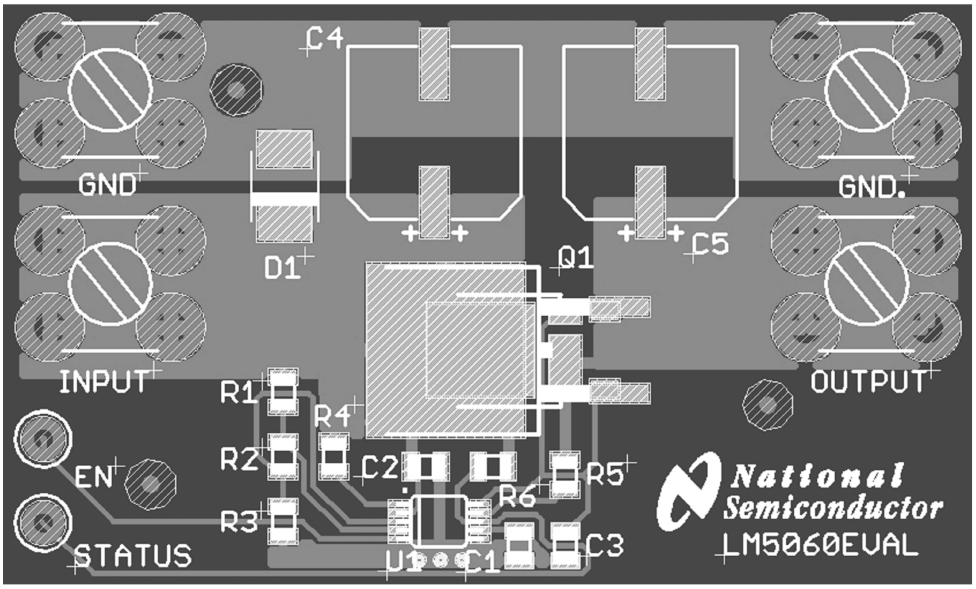

Figure 9. Evaluation Board, Top Side (Component)

Figure 10. Evaluation Board, Bottom Side

13 Bill of Materials (BOM)

ID	Description	Manufacturer	Part Number
U1	LM5060	Texas Instruments	LM5060
C1	Capacitor: 0.1 µF; 50 V; ±10%; X7R; MLCC; 0603	TDK Corporation	C1608X7R1H104K
C2	Capacitor: 0.1 µF; 100 V; ±10%; X7R; MLCC; 0805	TDK Corporation	C2012X7R2A104K
C3	(Not Installed)	n/a	n/a
C4	Capacitor: 22 µF; 100 V; Aluminum Electrolytic; SMT	Panasonic - ECG	EEE-HA2A220P
C5			
D1	Diode: TVS; 600W; 51 V; SMB	Diodes Inc	SMBJ51A-13-F
Q1	MOSFET: N-Channel; 100 V; 40A; 0.025Ω; D^2PAK	Vishay/Siliconix	SUM40N10-30-E3
R1	Resistor: 200 kΩ; 0.10W; ±5%; Thick Film; 0603	Vishay/Dale	CRCW0603200KJNEA
R2	Resistor: 38.3 kΩ; 0.10W; ±1%; Thick Film; 0603	Vishay/Dale	CRCW060338K3FKEA
R3	Resistor: 14.0 kΩ; 0.10W; ±1%; Thick Film; 0603	Vishay/Dale	CRCW060314K0FKEA
R4	Resistor: 9.09 kΩ; 0.10W; ±1%; Thick Film; 0603	Vishay/Dale	CRCW06039K09FKEA
R5	Resistor: 0.00Ω; 0603	Vishay/Dale	CRCW06030000Z0EA
R6	Resistor: 100 kΩ; 0.10W; ±1%; Thick Film; 0603	Vishay/Dale	CRCW0603100KFKEA
INPUT	Terminal: 6-32 Screw; Vertical; Snap-In PCB Mount; 15A	Keystone Electronics	7693
OUTPUT			
GND			
GND.			
EN	Test Point Terminal: PCB Miniature; 0.040in Dia Mtg Hole; White	Keystone Electronics	5002
STATUS			

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers’ products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers’ products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have ***not*** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products		**Applications**	
Audio	www.ti.com/audio	Automotive and Transportation	www.ti.com/automotive
Amplifiers	amplifier.ti.com	Communications and Telecom	www.ti.com/communications
Data Converters	dataconverter.ti.com	Computers and Peripherals	www.ti.com/computers
DLP® Products	www.dlp.com	Consumer Electronics	www.ti.com/consumer-apps
DSP	dsp.ti.com	Energy and Lighting	www.ti.com/energy
Clocks and Timers	www.ti.com/clocks	Industrial	www.ti.com/industrial
Interface	interface.ti.com	Medical	www.ti.com/medical
Logic	logic.ti.com	Security	www.ti.com/security
Power Mgmt	power.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Applications Processors	www.ti.com/omap	**TI E2E Community**	e2e.ti.com
Wireless Connectivity	www.ti.com/wirelessconnectivity		

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265